

Cities and Climate Change: Adaptation in London, UK

Alex Nickson

**Case study prepared for
Cities and Climate Change:
Global Report on Human Settlements 2011**

Available from <http://www.unhabitat.org/grhs/2011>

Alex Nickson is Strategy Manager for Climate Change Adaptation and Water, Greater London Authority (GLA). The GLA is the regional government for London, led by the Mayor of London. Alex Nickson's role is to develop a Climate Change Adaptation Strategy for London, to mainstream adaptation across the GLA and to work with representatives of London's key sectors to encourage and enable exponents of good adaptation practice.

Disclaimer: This case study is published as submitted by the consultant, and it has not been edited by the United Nations.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations concerning the legal status of any country, territory, city or area, or of its authorities, or concerning delimitation of its frontiers or boundaries, or regarding its economic system or degree of development.

The analysis, conclusions and recommendations of the report do not necessarily reflect the views of the United Nations Human Settlements Programme, the Governing Council of the United Nations Human Settlements Programme or its Member States.

Cities and Climate Change: Adaptation in London, UK

Alex Nickson

1. Introduction

All cities are vulnerable to climate impacts because of the density of people and assets in a relatively small area, and their dependence upon imported resources and utility networks to survive and thrive. London, as a growing world city located on an estuarial river in a water-stressed part of the UK faces particular challenges from climate change.

The Mayor of London is developing a Climate Change Adaptation Strategy for London¹ to protect and enhance the quality of life of Londoners and to help London and Londoners prepare for the impacts of climate change and extreme weather. The draft Adaptation Strategy was published for public consultation in February 2010, and the final strategy will be adopted during the summer 2010. This paper draws significantly from the draft Adaptation Strategy.

The UK Climate Impacts Programme provides the future climate projections for the UK.² Climate change will mean that south-east of England will experience progressively warmer, wetter winters, and hotter, drier summers. On top of these changes to our average climate will be an increase in the frequency and intensity of extreme weather events, such as heatwaves, tidal surges, storms and heavy rainfall. By the latter part of this century, an extreme weather event of a magnitude that might happen once every 100 years today, may occur every three or four years, and a new intensity will define the 'once in a 100 years' event. Sea levels will continue to rise for centuries.

This paper sets out the rationale for why London needs to adapt to climate change, how the Greater London Authority (GLA) have identified and prioritised the climate risks facing London, and actions proposed to manage these risks. The paper concludes with a number of lessons that the GLA has learnt in working to understand its climate risks and in initiating risk management actions.

2. Why Adapt?

London needs to adapt to climate change for five reasons:

1. London is not very well adapted to its current climate – 'extreme' weather in 2000, 2002, 2003, 2006, 2007 and 2009 have had a negative impact on the city. Actions to adapt to tomorrow's climate should therefore help buffer the city from the extremes of today's.
2. Some climate change is now inevitable – carbon dioxide remains in the atmosphere for about 100 years. The world is therefore still subject to the emissions of the past, and yet to experience the changes that will be brought about by the emissions of today and future emissions.
3. Climate change will mean that London will experience an increasing risk of floods, droughts and uncomfortably hot weather. Without action to manage these risks, the impacts from the changing climate will increasingly affect the prosperity of the city and the quality of life for all Londoners, but especially the most vulnerable in society.

1. GLA, 2010.

2. http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=163&Itemid=293.

4. As highlighted by the Stern Review³ and demonstrated by Hurricane Katrina and numerous other climate impacts, actions taken before an extreme weather event are more effective and less costly than retrospective actions.
5. London's population is projected to grow by over a million people over the next two-three decades. Unless this growth is located and designed to be climate resilient, it will add to the adaptation 'hangover' provided by the existing development.

3. London's Approach

The GLA have analysed how London is vulnerable to weather related risks today (and so established a baseline to assess how these risks change) and then used climate projections from climate models to identify how climate change accentuates existing risks and creates new risks, or opportunities in the future. This enables the GLA to assess and prioritise the key climate risks to London. The GLA are in the process of developing a Climate Change Adaptation Strategy for London that provides a framework to identify actions where the Mayor is uniquely placed to act, where other stakeholders (individually or collaboratively) can and should act, and where further work is required to understand the climate and / or impacts before actions can be defined.

The risk assessment used defines risk as:

$$\text{Risk} = \text{probability} \times \text{consequence}$$

Where **probability** is defined as the likelihood of an event (for example a tidal surge), or change occurring that exceeds the ability to cope with it and therefore has an impact, and the **consequence** of that impact upon a receptor (who and what is affected and how severely affected are they). Consequence is determined by the **exposure** of the receptor (for example being located on the ground floor of a building in a flood zone), and the **vulnerability** of the receptor (how sensitive are they / it to the impact, for example, what is their ability to respond to an impact).

In essence, the risk assessment helps to identify 'who and what' is vulnerable to climate impacts and to determine how and why they are vulnerable. This then enables the GLA to prioritise measures to manage or reduce the risk by either reducing the probability of an impact occurring, and / or seeking to reduce the consequence (by reducing the exposure and / or sensitivity of the receptors).

The risk assessment has highlighted that London is vulnerable to three key climate risks:

1. Floods.
2. Droughts.
3. Overheating.

4. Flood Risk

Context

London is vulnerable to flooding from three principal sources of flood risk:

1. Tidal flooding from the North Sea, principally due to tidal surges.
2. Fluvial flooding from the freshwater River Thames and the tributaries to the Thames.
3. Surface water flooding when the drains are overwhelmed by heavy rainfall.

3. HM Treasury, 2005.

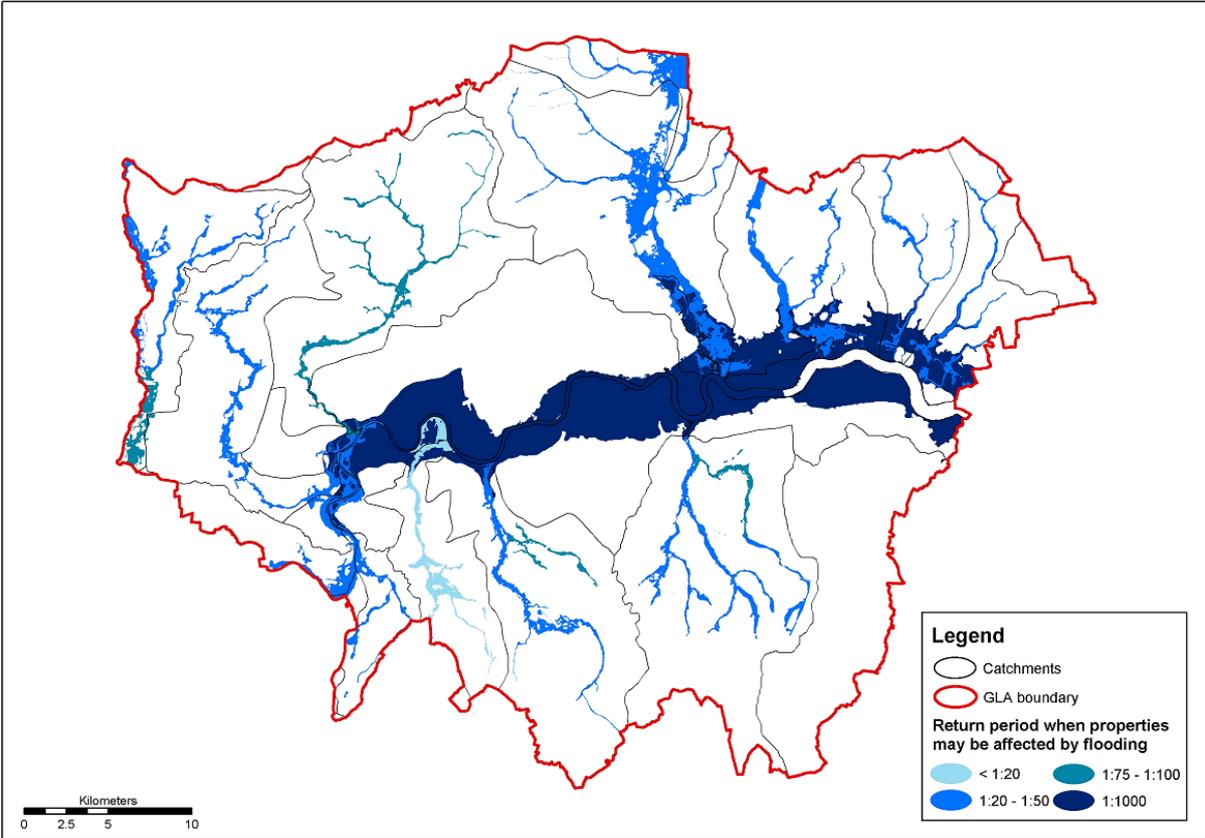
London is protected from flooding by the flood defences along its rivers and the drainage network. Fifteen per cent of London’s area lies on the former floodplains of London’s rivers, and whilst the Thames tidal flood defences provide some of the best standards of flood defence in the world, the standard of protection along the freshwater Thames and the tributaries to the Thames are much lower, and very variable. The standard of protection provided by the drainage network is very low.

Determining the baseline

The standard of protection provided by the flood defences and the area they protect defines the probability of being flooded today. This area can be mapped – Figure 1 shows the fluvial and tidal flood risk in London.

The picture for surface water flood risk is more complex, as surface water flooding is less predictable. This is because the storms that are usually responsible for heavy rainfall (for example, summer convective storms) tend to be very localised and extremely unpredictable, combined with the fact that the drainage system is designed for high frequency, low volume rainfall, and therefore its ability to prevent flooding depends upon its state of maintenance, how much water is in it before the storm and the intensity of the rainfall. That said, low-lying areas will be more susceptible to flooding as water will naturally run to them and pond there if there is no drainage / insufficient drainage capacity, and these areas can be identified and mapped.

Figure 1. Map of tidal and fluvial flood risk in London



Source: GLA, 2010, citing Environment Agency.

Note: The red outline marks the Greater London Authority boundary.

The number of people and assets in the flood risk areas can be analysed to determine who and what is at risk. This analysis shows that there are 1.25 million people, 481,180 properties, 441 schools, 75 underground stations and 49 railway stations located in areas of tidal and fluvial flood risk.⁴ A significant proportion of London's emergency services – 10 hospitals, 46 police stations and 20 fires stations are also at risk.

Considering the factors that contribute to exposure (e.g. living on the ground or lower-ground floor, having limited advance warning of a flood) and vulnerability (e.g. age, health, disability, proficiency of spoken English, living alone or not having a support network, income and insurance cover) provides further detail on the potential consequences of a flood.

The baseline assessment shows that for flood risk today:

- A significant proportion of London's population lives and works at risk of flooding, though the probability of being flooded is low.
- The poorest in the city are more likely to live at tidal and fluvial flood risk (though more affluent people also live in areas of fluvial flood risk).
- There is a low level of public awareness of flood risk and what action to take to prepare or respond to a flood.
- There is a lower uptake of insurance for people in social housing, or on low incomes.
- Few people at flood risk are registered to receive flood warnings, so are unable to make use of even short advance warnings of a potential flood.
- A significant proportion of London's critical infrastructure lies in areas of flood risk, including emergency services and utilities that London would be reliant upon to be operational during, or manage the impacts of a flood.
- The growth in London's population will increase the number of people living and working on the floodplain, plus the associated assets.

Projecting the future

The probability of flooding in the future is projected to increase because:

- Sea levels are projected to rise by approximately 1 metre over the century (and possibly 2 metres under an extreme scenario).
- Tidal surges may increase in height by up to 0.7 metres by the end of the century.
- Wetter winters, with more frequent and intense heavy rainfall event will mean that peak river flows are expected to increase by between 20–40 per cent by the end of the century.

The projected changes means that, assuming no flood risk management measures are taken, climate change will increase not only the frequency of flooding in London, but the extent and depth of flooding.

Flood risk management measures

The UK Environment Agency initiated a project known as the Thames Estuary 2100 Project⁵ (TE2100) in 2002 to identify the next generation of strategic flood risk management options for London and the Thames Estuary. The TE2100 project focuses on the increases in flood risk on the tidal Thames.

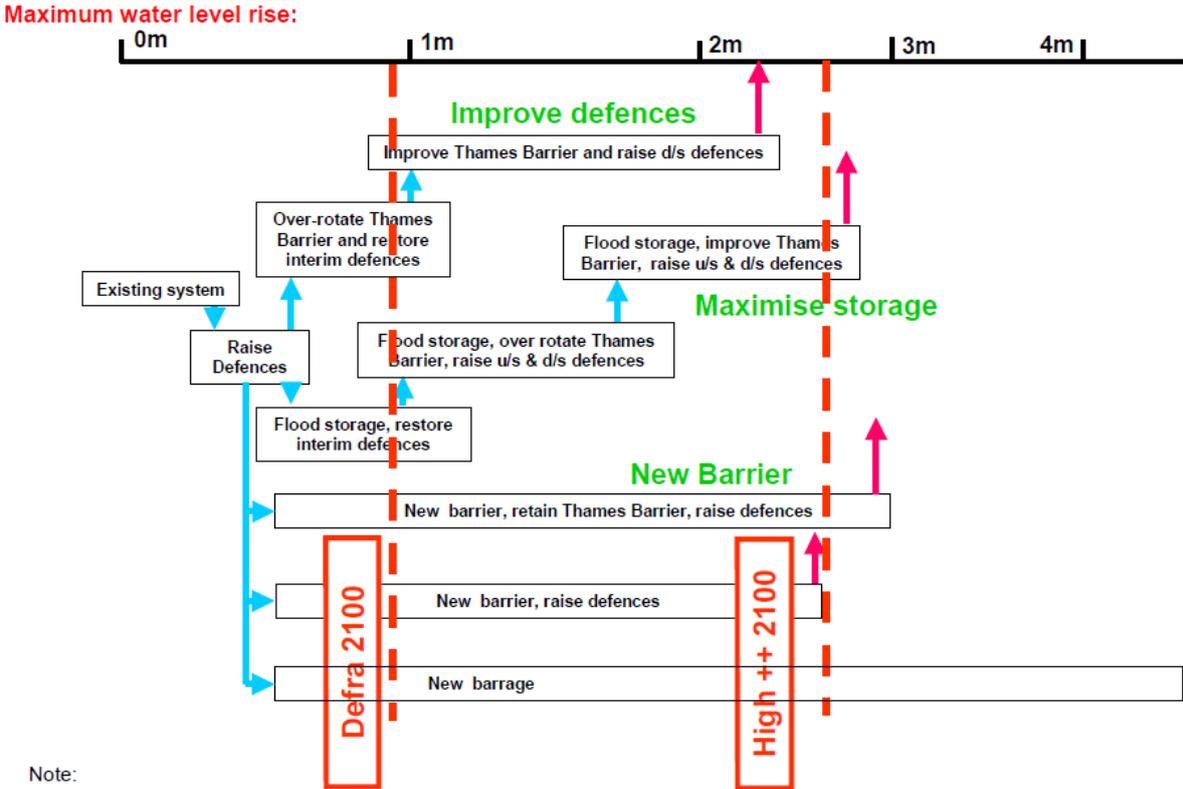
4. GLA, 2009a.

5. The draft plan can be downloaded from www.environment-agency.gov.uk/te2100.

The TE2100 project developed a series of ‘decision pathways’ to provide a flexible approach to managing the uncertainty associated with predicting sea level rise. The decision pathways approach involves identifying the thresholds at which various flood risk management measures fail to provide an acceptable level of protection, plus the trigger points where a different approach to managing flood risk is required in response to a higher sea level rise (for example when to switch from raising flood defences and improving storage to planning for a second barrier). These decision pathways are shown below in Figure 2, together with the indicative rises in water level they can manage (shown by the pink arrows). The red dotted lines show the projected increase in water levels from two scenarios.

In all but the most extreme scenarios, the current Thames Barrier and tidal defences will continue to protect London for decades to come, and it is unlikely that a new barrier will be required before the end of the century. Spatial planning will need to ensure that flood vulnerable land uses are not put in high-risk areas and that opportunities are taken to set developments back from the river’s edge to allow improvements to the flood defences to be undertaken.

Figure 2. Thames Estuary 2100 Project (TE2100) ’decisions pathway’



Note:
Each box represents one or more portfolios of responses

Source: GLA, 2010, citing Environment Agency.

Notes: The flood risk management options are plotted against the maximum level of protection against sea level rise that they can provide. The right hand dotted line shows the worst case sea level rise scenario to the end of the century (u/s = upstream, d/s = downstream).

The Thames Barrier is composed of a series of metal gates between concrete piers across the river. The gates normally lie flat on the bed of the Thames. When the Barrier closes, the gates are rotated into a vertical position to shut out the tide. By increasing the height of the gates and over-rotating them beyond the vertical position, it is possible to increase the amount of sea level rise the Barrier can protect against.

The increase in peak river flows on the freshwater Thames presents a significant challenge as there is less opportunity to raise the height of the flood defences due to the proximity of existing development to the river's edge. Using green spaces adjacent to the Thames to store floodwater may be necessary towards the end of the century. Some existing riverside properties may have to be made resilient to flood damage.

The combination of low standards of protection, short warning times and relatively few management options means that managing flood risk on the tributaries to the Thames is a priority. Again this will need to focus on raising flood defences and creating flood storage where possible, but these options are very limited and expensive to implement, so in the short-to-medium term, the GLA will work with the Environment Agency to improve local flood warnings, and build local resilience and capacity to act where the probability cannot be reduced.

Heavier and more seasonal rainfall will also increase surface water flood risk in London. The low permeability of London's urban landscape, new development pressures and the poor maintenance of parts of the drainage network magnify this risk. Currently, responsibility for managing surface water flood risk is spread across several organisations and there is therefore no single agency owning the risk. The Mayor has created a multi-agency partnership to bring together all the bodies with information on and responsibility for surface water in London. This partnership, known as the Drain London Forum is now working to map surface water flood risk and to identify and prioritise areas of high risk as part of developing a surface water management plan for London.

5. Drought

Context

Eighty per cent of London's water comes from the River Thames and the River Lee. It is pumped from these rivers when river levels are high and stored in reservoirs around London. The remaining 20 per cent comes from the aquifer underneath London. Both the rivers and the aquifer are fed by rainfall, mostly in winter.⁶

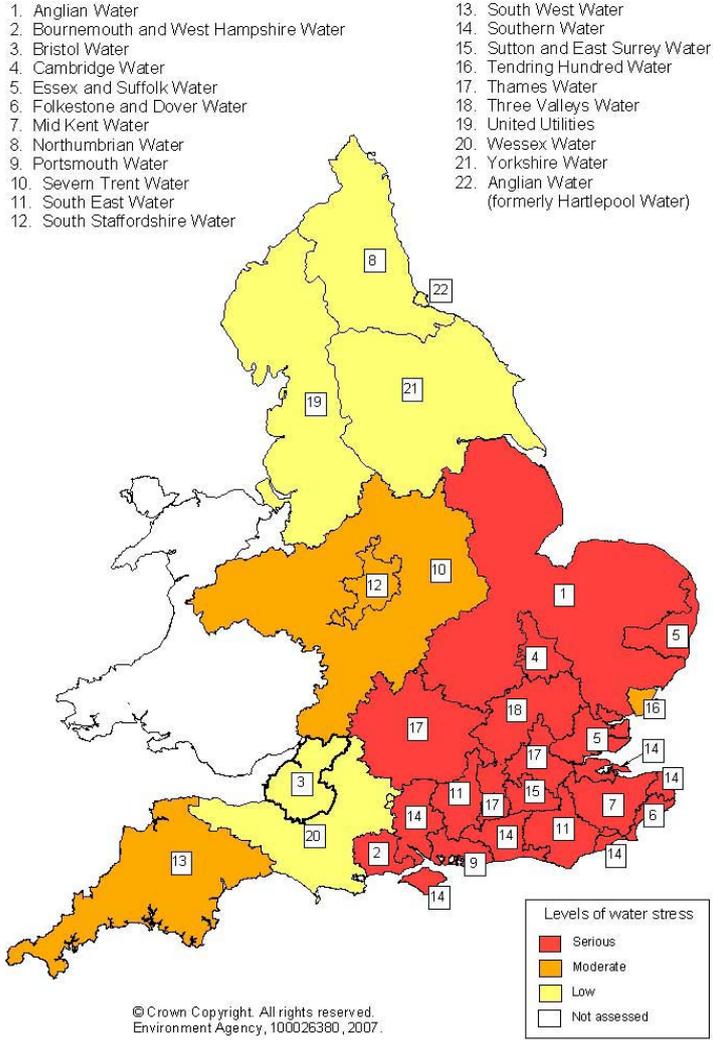
An annual average of 690mm of rain falls in the Thames catchment. Two-thirds of this is lost through evaporation. More than half of the remaining volume is then abstracted for consumption, leaving less than 45 per cent of the 'effective' rainfall for wildlife. The large population living in the south-east of England, combined with the relatively low rainfall means that the region is classified as 'seriously water stressed' by the UK Environment Agency⁶ – a term that means that the amount of water abstracted from the environment is causing actual damage to the environment (see Figure 3).

Each Londoner consumes an average of 163 litres of water per day, compared to the national average of 150 litres per person per day. This increased consumption is primarily linked to affluence (more water consuming devices per home) and lower occupancy rates (smaller household units, such as flats, each with water consuming devices). In addition, only one in five households has a water meter, so currently only 20 per cent of Londoners have an incentive to save water.⁶

Over 600 million litres of treated water per day, nearly a quarter of all the water distributed in the mains network, is lost in leakage. This is due to the fact that nearly a third of the pipes that make up the distribution network are more than 150 years old. London clay is corrosive and

6. Environment Agency, 2007.

Figure 3. Water stress in the southeast of England



Source: Environment Agency, 2007

weakens pipes that are then subjected to ground instability, as London’s clay soils shrink and swell as the soil moisture content changes seasonally.⁶

Determining the baseline

The probability of a drought persisting long enough to require drought management measures to be enforced in London is low. Water companies in the UK are required to invest in measures to ensure a good security of supply and have good drought management plans. However, London experienced a significant drought in 2004–2006 which highlighted that a prolonged drought period can present substantial challenges.

The main impacts of a drought are upon the environment and those affected by drought management measures (for example bans on using hosepipes, and using water for non essential uses, such as cleaning trains etc.).

Projecting the future

Droughts are expected to become more frequent as climate change accentuates the seasonality of rainfall. Hotter, drier summers will increase the demand for water from people and wildlife, whilst the increased rainfall from wetter winters may not be able to be captured, either in reservoirs or infiltrate to replenish the aquifer. The greater seasonal fluctuation in soil moisture content will also cause increased soil movement, affecting the pipes of the mains water distribution network, increasing leakage.

Drought measures may have to be applied more frequently, starting earlier in the year and persisting for longer. This will affect businesses dependent on water-consuming devices or leisure pursuits. An increased frequency and longevity of droughts will also have a significant impact on London's watercourses and wetlands.

Drought management measures

It is not possible to prevent a drought, but by reducing the demand for water, it is possible to increase the length of time it takes before drought measures are required. Using less water also reduces carbon emissions and saves money (nearly 90 per cent of the carbon emissions associated with water abstraction, purification, distribution, use and effluent treatment is in the home, primarily from heating water for washing). The Mayor has published a draft Water Strategy for London⁷ that sets out his preferred approach to balancing supply and demand for water as a hierarchy of options:

- 'Lose less' – reduce the loss of water through better leakage management.
- 'Use less' – improve the efficiency of water use in residential and commercial development (both new and existing).
- 'Reclaim more' – use reclaimed water for non-potable uses (rainwater harvesting and 'grey water' recycling).
- 'Develop new resources' – look at new resource options that have the least environmental impact.

Thames Water, the main water supply company to London spends approximately £1 billion per year⁸ replacing aged water mains pipes in London. However it will take many years before the levels of leakage in London nears levels of international good practice.

6. Overheating

Context

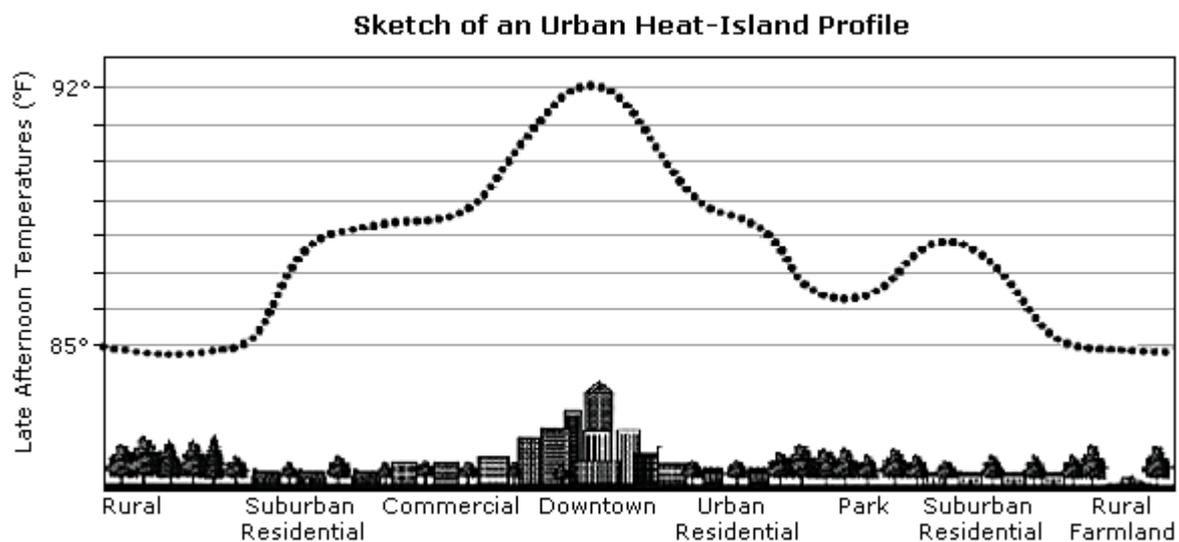
'Overheating' is a term used to describe when temperatures rise to a point where they affect the health and comfort of Londoners.

London's summers are still comparatively mild enough for health impacts due to high temperatures to be limited to rare, extremely hot weather events, such as heatwaves. Over the period of 1977–2006 London's average summer temperatures have been getting progressively warmer and the temperatures of the hottest days have been rising even more quickly. It is projected that by the middle of the century, the average summer will be as hot as a heatwave (defined as hotter than 32°C) today.

7. GLA, 2009b.

8. Thames Water, 2009.

Figure 4. Profile of urban heat island



Source: GLA, 2010.

The August 2003 heatwave is infamous for the number of people that died across Europe. It is less appreciated that at least 600 people in London died as a result of the high temperatures. The impact of the 2003 heatwave was greater in London than in other regions, despite the fact that London did not experience the highest temperatures. The urban heat island effect is thought to have been a significant factor in the number of deaths during the 2003 heatwave.

The urban heat island refers to the warmer temperatures experienced within cities compared to rural areas around them. The urban heat island is caused by urban materials absorbing heat from the sun during the day and releasing this heat at night, preventing urban areas from cooling off as quickly as rural areas. In combination with the heat generated from energy use, plus the reduced cooling benefits from greenspaces, the centre of London can be 4°C warmer than the rural surroundings. During heatwaves, the intensity of urban heat island can be up to 10°C.⁹

Baseline

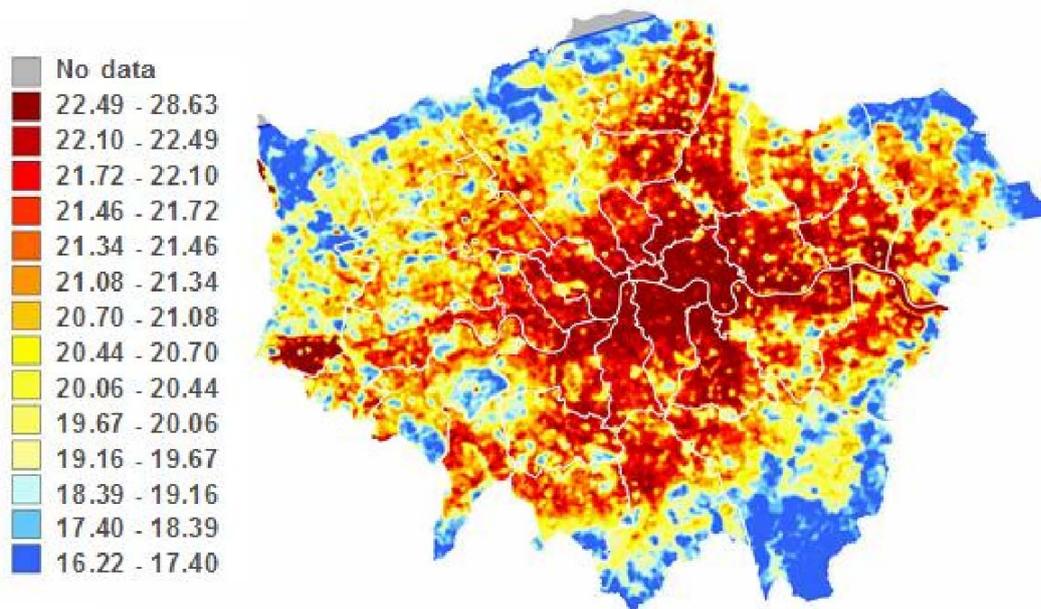
Differentiating overheating risk is complex because heatwaves tend to affect large geographic areas, and because individual rooms within buildings respond differently to temperatures. In London, the GLA have mapped the intensity of the urban heat island as a proxy for mapping the risk of overheating. Figure 5 shows the surface temperature of London during the 2006 heatwave. It can be seen that temperatures vary considerably across the city with the highest temperatures corresponding to the high-density developed areas and the coolest temperatures corresponding to the major parks and rural fringe.

The consequences of prolonged high temperatures are:

- An increase in heat related discomfort, illness and death.
- An increase in demand for energy intensive cooling, such as air-conditioning, leading to an increased frequency in power shortages.

9. GLA, 2006.

Figure 5. Surface temperature (°C) in London at 21.43pm on 12 July 2006



Source: GLA, 2010, citing NASA / LUCID).

- An increase in social inequality relating to those that live in poorly designed and / or overcrowded buildings and who have limited capacity to take measures to reduce or escape the heat.
- A rise in the demand for water, increasing pressure on limited water resources.
- Damage to temperature-sensitive infrastructure.

Individual days do not appear to have a significant impact on the health of Londoners, or on London's infrastructure.

Projecting the Future

London will experience an increasing risk of overheating risk due to:

- rising summer temperatures and increased frequency and intensity of heatwaves due to climate change (average summer temperatures will rise by 2.7°C and very hot days by 6.5°C by the middle of the century).
- the intensification of the urban heat island effect due to climate change (more cloud free days will mean more days when an intense (>4°C) urban heat island is experienced).
- the intensification of the urban heat island due to London's growth (increasing the density of the city will increase the intensity of the urban heat island and the size of the areas experiencing elevated temperatures)
- the intensification of the urban heat island due to an increase in anthropogenic heat contributions from energy use in response to the rising temperatures and the growth in population.

The model used in the UK Climate Projections 2009 represents the UK land cover as rural, and therefore cannot model the urban microclimate to understand the interaction between the urban climate and climate change. The Greater London Authority is working with a

consortium of universities¹⁰ to model how the urban climate responds to climate change and the effect of strategic and local scale interventions. This work involves inserting an ‘urban tile’ into the regional climate model (the urban tile uses a different energy balance model to represent the urban land form).

Overheating risk management measures

The GLA proposes pursuing four parallel courses of action to manage and reduce overheating risk in London:

1. offsetting the urban heat island to reduce the intensification of high temperatures by the urban heat island effect through ‘urban greening’ measures (see key actions below).
2. designing new and adapting existing buildings and infrastructure to minimise the need for cooling as far as possible. This will principally focus on providing London-specific design guidance for developers and their advisers.
3. ensuring that where active cooling is still required that low-carbon, energy efficient measures are used. The GLA has set a target of 25 per cent of its energy coming from decentralised energy by 2025.
4. helping Londoners adapt their behaviour and lifestyles to higher temperatures.

Following the 2003 heatwave, a UK-wide heatwave plan was developed.¹¹ This has been updated every year and regional health and social care delivery bodies are required to adapt the national plan for local circumstances. In London, a heatwave is declared when temperatures greater than 32°C by day and 18°C by night are forecast for three consecutive days. A key part of the plan relies upon General Practitioners being able to identify and assist ‘vulnerable’ people – something which in practice is very difficult to do due to fact that some of the key factors that make people vulnerable to high temperatures (e.g. medical conditions, having carers) vary from week to week, combined with the fact that many ‘vulnerable’ people do not perceive themselves as vulnerable. One solution to this problem is greater community cohesion, but this is very difficult to foster.

7. Key Actions

The draft London Adaptation Strategy proposes a ‘roadmap to resilience’, detailing the actions that will enable London to become better adapted to the changing climate and extreme weather. The actions include:

- Undertaking an ‘urban greening programme’ to use the benefits of vegetation and greenspaces to cool the city, absorb and retain floodwater and support biodiversity. The programme will focus on:
 - Increasing tree cover by 5 per cent to 25 percent by 2025.
 - Increasing greenspace cover in central London by 5 per cent by 2030 and a further 5 per cent by 2050.¹²
- Enabling the delivery of 100,000m² of green roofs by 2012 (currently London has 340,000m² of greenroofs).

10. The Development of a Local Urban Climate Model and its Application to the Intelligent Design of Cities (LUCID) <http://www.lucid-project.org.uk/>.

11. Department of Health, 2009.

12. The baseline is currently being defined.

- Improving the water and energy efficiency of existing housing stock through a programme¹³ of retrofitting up to 1.2 million homes by 2015 (this will save, on average, £62 on household utility bills and equates to 46,000 litres of water and 0.48 tonnes of CO₂ per home per year).
- A strategic flood risk management programme to reduce surface water flooding by improving the permeability of the city (through urban greening) and upgrading the drainage network in critical areas.
- Ensuring that adaptation is mainstreamed through the Greater London Authority and its delivery bodies and helping the 33 London Boroughs to do the same.

8. Five Lessons from London

1. ***Make adaptation part of your day job*** – adaptation is not about creating lots of new policies, but about routinely considering how the future climate may affect the outcomes of your decisions and using that understanding to make more informed decisions. Adaptation needs to be mainstreamed across your organisation – planning, building design, emergency planning, procurement etc all need to become climate risk aware. Integrated adaptation will require partnership working across sectors. Key players across various sectors need to ‘own’ the risks facing them and helped to share good practice.
2. ***Understand your vulnerabilities*** – look at how climate risks compare to other risks. Analyse who and what is affected and why and how they are vulnerable.
3. ***Climate models are tools not answers*** – unless you understand your sensitivities to the climate (i.e. the thresholds at which impacts occur), then climate models, particularly the latest generation of probabilistic, downscaled models cannot be properly used.
4. ***Don’t use the past as a guide to the future*** – climate change may increase the frequency and intensity of extreme weather events and change seasonal trends over the longer term.
5. ***Adaptation is for life*** – because the climate will keep changing, your responses will need to be dynamic and evolve as the risks change. There is therefore, no steady state of being ‘adapted’. Adaptation actions will need to be regularly reviewed to ensure they continue to provide an acceptable level of risk management. Ensure that you actions today don’t foreclose options tomorrow.

References

- Department of Health (2009) *Heatwave Plan for England 2009*, http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_099015
- Environment Agency (2007) *Areas of Water Stress: final classification*, <http://publications.environment-agency.gov.uk/pdf/GEHO1207BNOC-e-e.pdf>
- GLA (Greater London Authority) (2006) *London’s Urban Heat Island: A Summary for Decision Makers*, GLA, London, http://legacy.london.gov.uk/mayor/environment/climate-change/docs/UHI_summary_report.rtf

13. <http://www.lda.gov.uk/server.php?show=ConWebDoc.3429>.

- GLA (2009a) *London Regional Flood Risk Appraisal*, <http://legacy.london.gov.uk/mayor/strategies/sds/docs/regional-flood-risk09.pdf>
- GLA (2009b) *The London Water Strategy, draft for public consultation*, <http://legacy.london.gov.uk/mayor/environment/water/index.jsp>
- GLA (2010) *The draft climate change adaptation strategy for London. Public Consultation Draft*, GLA, London, http://www.london.gov.uk/climatechange/sites/climatechange/staticdocs/Climate_change_adaptation.pdf
- HM Treasury (2005) *Stern Review on the Economics of Climate Change*, <http://www.oce.gov.uk/activities/stern.htm>
- Thames Water (2009) *Statement of Response: Draft Water Resource Management Plan*, <http://www.thameswater.co.uk/cps/rde/xchg/corp/hs.xsl/5373.htm>